

Expendable Cooling for a One-Day Venus Lander Concept

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Project Objective:

Develop a thermal architecture which would enable a day-long Venus Lander Mission using an expendable coolant technique.

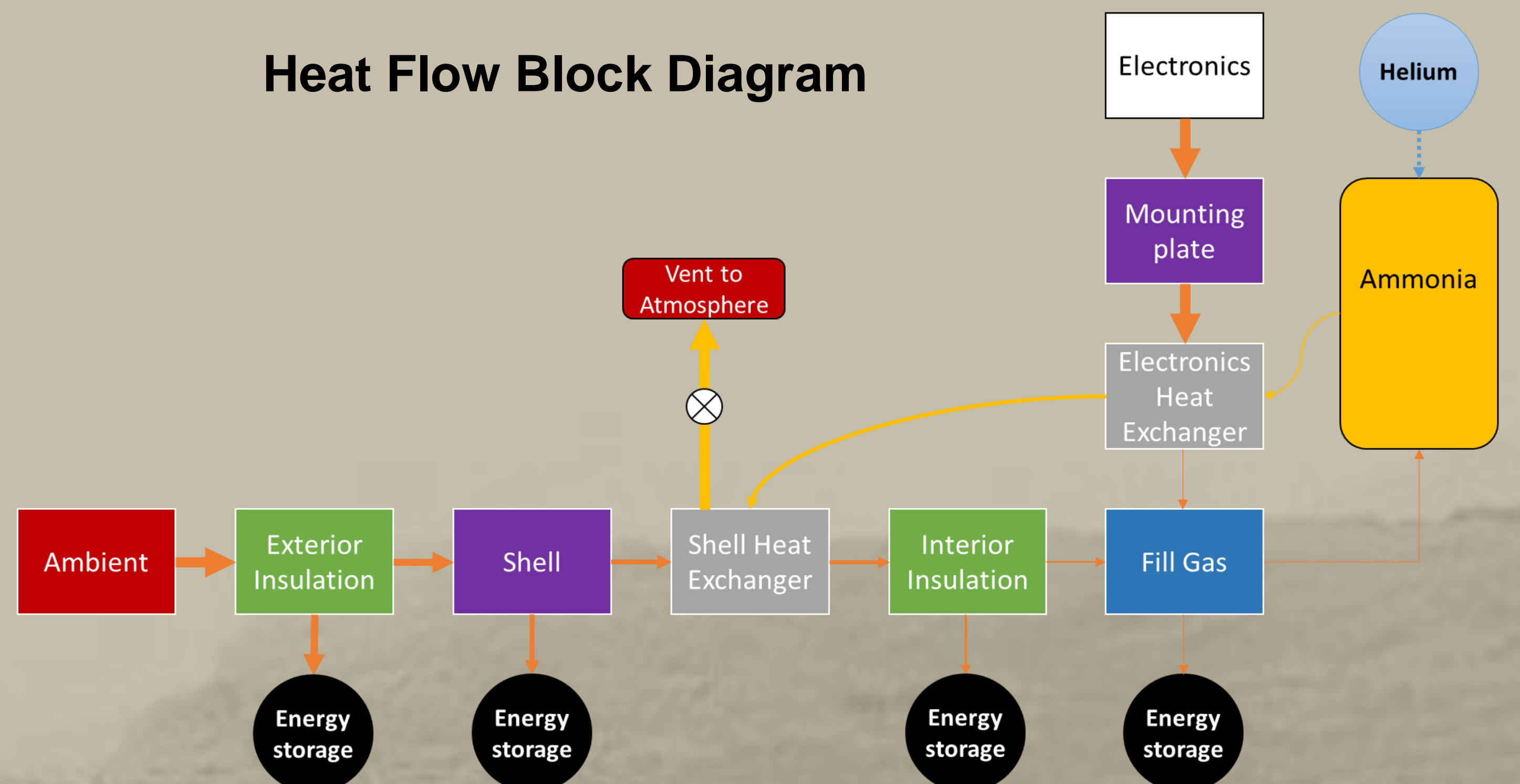
Benefit to NASA and Venus Surface Science:

Enables a mission with unprecedented science capabilities for Venus surface exploration.

Allows “human-in-the-loop” science interaction with the Lander.

Scientists could guide instruments to specific targets rather than blind autonomous instrument placement.

Heat Flow Block Diagram



Methodology:

Expendable Cooling System Development

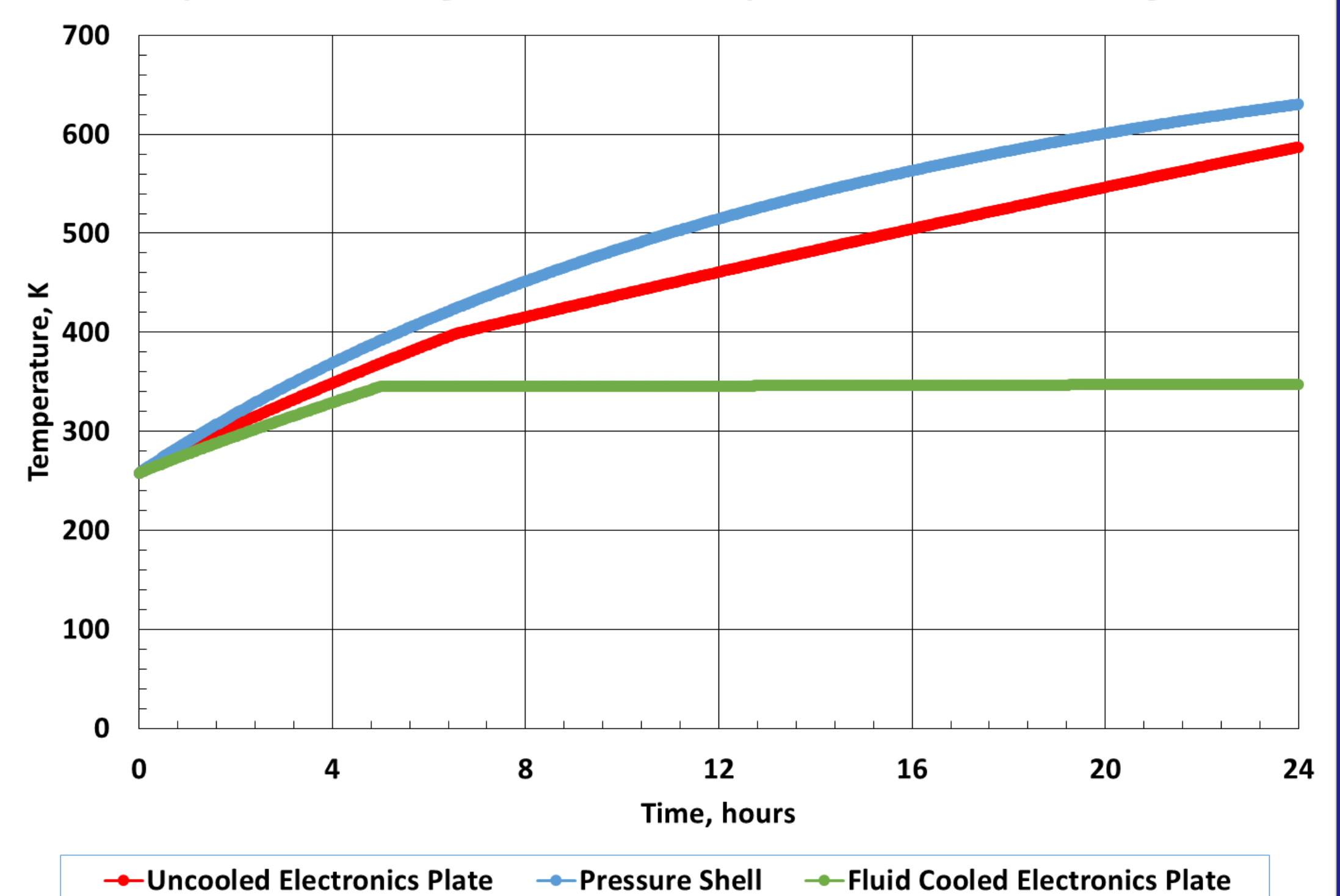
- ☐ Candidate working fluids: Water, ammonia and aqua-ammonia mixtures
- ☐ Thermodynamic process model evaluates performance of working fluids
- ☐ Developed a two-stage heat transfer process model
 - First stage is a constant volume heating process model of startup
 - Second stage is a constant pressure heating process with fluid flow
 - Determined pure ammonia fluid provides best lifetime performance

- ☐ Required ammonia mass is 60 kg
- ☐ Identified locations in Lander design to accommodate ammonia storage
- ☐ System is pressurized with helium
- ☐ Model validation by experimental demonstration of cooling process

Thermal System Architecture

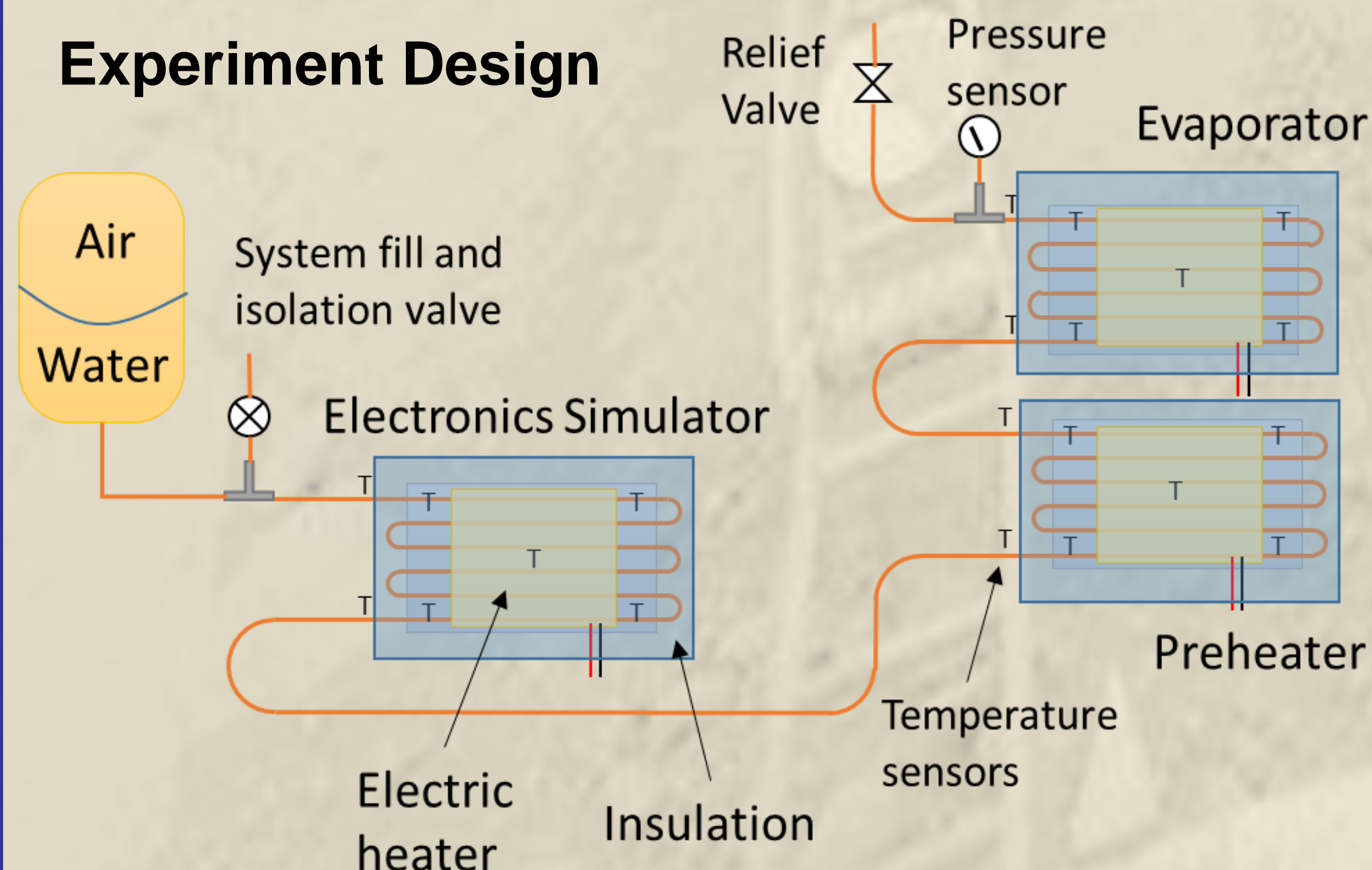
- ☐ Insulation on exterior and interior surfaces of the pressure vessel shell
- ☐ Interior filled with CO₂ gas at 1 bar pressure
- ☐ Beryllium equipment shelves for high thermal capacity
- ☐ Expendable coolant vented to Venus atmosphere

Expendable Cooling Performance Compared to Non-cooled Design



In the above figure, the performance of the expendable cooling system with 60 kg of ammonia is compared to a “dry” system where no cooling is available for the electronics. The first 5 hours of the mission would utilize a constant volume heating process to limit the temperature rise of the electronics. After the ammonia system pressure exceeds that of the Venus atmosphere, the fluid would vent and fluid flow would continue to cool the electronics and the pressure vessel shell.

Experiment Design



◀ The left figure shows the design of an experiment to validate the heat transfer model of the Venus lander expendable cooling system. The experiment simulates the heat load generated by the electronic and the heat load absorbed by the pressure vessel shell.

▶ The right figure shows a schematic of a Venus Lander concept incorporating the expendable coolant thermal system. The pressure vessel shell has insulation on its exterior and interior surfaces. An ammonia reservoir would be located in vacant region at the bottom of the vessel and is pressurized by a separate helium tank (not shown).

